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Ultrasound Based Measurement of 'Carotid Stenosis >70%': An Audit of UK Practice

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Objectives. *To determine velocity thresholds for diagnosing 'carotid stenosis >70%' and whether Vascular Studies Units in the United Kingdom used ECST or NASCET measurement methods.*
Design. *Questionnaire to 102 members of the Society of Vascular Technology of Great Britain and Ireland.*
Results. *One quarter (26%) of respondents reported that their unit used the NASCET measurement method, 31% used the ECST method, while 43% did not know. When all velocity criteria were pooled and compared, an almost equal proportion of ECST, NASCET and 'do not know' respondents used a peak systolic velocity threshold of >230 cm/s as being diagnostic of a 'stenosis >70%'. Interestingly, this velocity is now the threshold proposed by a North American consensus group for diagnosing a NASCET stenosis of >70%.*
Conclusions. *This audit suggests that there is considerable confusion about what constitutes an ultrasound based diagnosis of 'stenosis >70% in the United Kingdom.*

Keywords: Carotid stenosis; Ultrasound.

Introduction

The international trials have clarified the role of carotid endarterectomy (CEA) in the management of selected patients with symptomatic[1,2] and asymptomatic disease.[3,4] Although similar in basic design, each used different methods for measuring 'degree of stenosis'. While these differences seemed relatively innocuous at the time, it now has important implications regarding implementing their conclusions in the 21st century.

Patients recruited into in the European Carotid Surgery Trial (ECST), the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the Asymptomatic Carotid Atherosclerosis Study (ACAS) underwent diagnostic angiography and each used the minimal residual luminal diameter as the numerator (Fig. 1). In ECST, the denominator was the estimated diameter at the same point, usually the carotid bulb. In NASCET and ACAS, the denominator was the diameter of a disease free point in the ICA above the stenosis where the walls of the vessel were parallel (Fig. 1).

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Table 1 clearly shows how the two measurement methods can produce different values for the same 'degree of stenosis'. For example a 65% NASCET stenosis is broadly equivalent to an 80% ECST stenosis.[5] However, by the time the Asymptomatic Carotid Surgery Trial (ACST) was recruiting, routine diagnostic angiography had largely been replaced by 'non-invasive' diagnostic imaging (notably duplex ultrasound). Accordingly, standardisation of 'stenosis severity' across all the participating centres was even more difficult to achieve. This potential problem was actually alluded to in the abstract of this paper,[4] where reference was made to including patients with 'substantial carotid narrowing'.

With the trend towards avoiding diagnostic angiography (because of procedural stroke risk), there has been much debate about how duplex compares with angiography in measuring carotid stenosis. Numerous validation studies have shown acceptable comparative accuracy, but what is rarely considered is which measurement method was being used for comparative purposes. There seems to be an implied assumption that we are all measuring the same thing. In North America there may be less potential for measurement discrepancies as they only use the NASCET angiographic method. In Europe, however, anecdotal evidence suggests that some centres use the ECST

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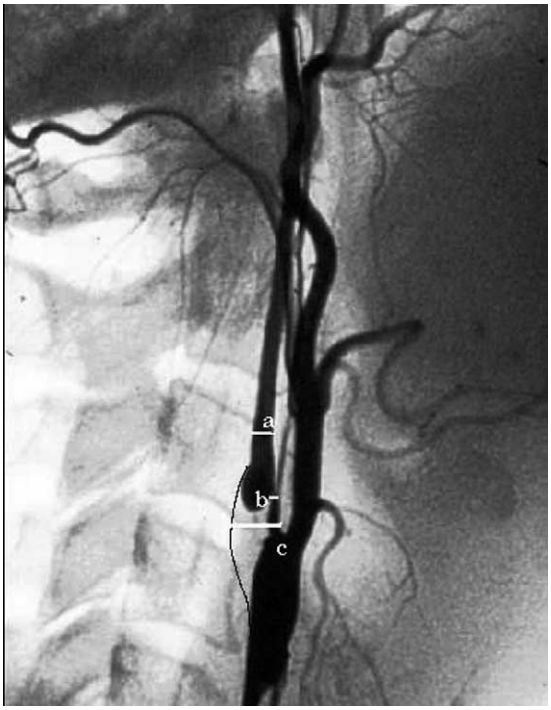

Fig. 1. ECST and NASCET methods for measuring stenosis. Both used the residual lumen diameter within the stenosis (white line b) as the denominator. ECST then 'estimated' the contour of the carotid bulb (black line) and used the vessel diameter at this level (white line c) as the numerator. Accordingly, ECST stenosis = 100 − (b/c × 100)%. In NASCET, the numerator was the diameter of a disease free point in the ICA above the stenosis where the walls of the vessel were parallel (white line a). Accordingly NASCET stenosis = 100 − (b/a × 100)%.

method while others prefer the NASCET. A survey of practice in the United Kingdom was, therefore, undertaken to determine velocity thresholds for diagnosing 'stenosis >70%' and whether Vascular Studies Units used ECST or NASCET based criteria.

Materials

A questionnaire was sent to members of the Society for Vascular Technology of Great Britain and Ireland (SVT). Two key questions were asked. First was to ascertain whether measurement of stenosis (in their unit) was calculated from a percentage reduction of the diameter of the lumen in comparison to the bulb (the ECST method, Fig. 1) or a percentage lumen diameter reduction in relation to a normal segment of distal ICA (NASCET method, Fig. 1). The second aim was to determine peak systolic velocity (PSV) and end diastolic velocity (EDV) criteria used to diagnose 'stenosis >70%' in their unit.

Results

Of the 102 responses, the majority were from Vascular Technologists or Clinical Vascular Scientists ($n=71$). Other disciplines included Sonographers ($n=19$), Radiographers ($n=5$) and Medical Physics technologists ($n=7$). The majority (63%) had >5 years of carotid scanning experience, while 86% had 2 or more years of carotid scanning experience. Two thirds of units (66%) performed >50 carotid scans per month, while about one third (36%) undertook >100 carotid scans per month. Just over half (52%) were based in Teaching Hospitals, while 49 (48%) worked in District General Hospitals. The vast majority (83%) indicated that all or most carotid operations were based on ultrasound imaging alone.

Of the 77 indicating which measurement method was employed in their Unit, 20 (26%) believed that their measurement method was NASCET based, 24 (31%) reported it was ECST, while the majority (43%) reported that they did not know.

Table 1. Comparison of NASCET (N) and ECST (E) methods for measuring carotid stenosis along with 1996 consensus ultrasound criteria

Angiographic diameter stenosis		Duplex velocity criteria				
N (%)	E (%)	PSV_{IC} (19,20)	EDV_{IC} (18–20)	PSV_{IC}/PSV_{CC} (21–23)	PSV_{IC}/EDV_{CC} (24,25)	EDV_{IC}/EDV_{CC}*
12	50	<120	<40	<1.5	<7	
30	60					<2.6
47	70	120–150	40–80	1.5–2	7–10	
60	77		80–130	2–3.2		
65	80	150–250				
70	83		>130	3.2–4	10–20	2.6–5.5
82	90	>250		>4	20–30	
90	95				>30	>5.5
99	99			Trickly flow		

Published with permission from 5. Minimum false positive and false negative tests. N, NASCET; E, ECST; PSV, peak systolic velocity; EDV, end-diastolic velocity; IC, internal carotid; CC, common carotid.

* Baker JD. Standardized imaging and Doppler criteria for cerebrovascular diagnosis using duplex sonography. Presented at AIUM, Las Vegas, NV, 1986.

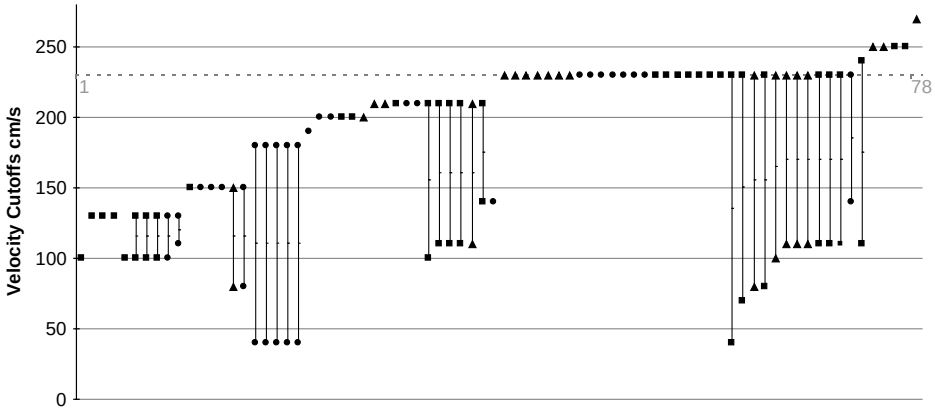

Fig. 2. Peak systolic velocity (PSV) and end-diastolic velocity (EDV) criteria for diagnosing 'stenosis >70%' in the United Kingdom. Those centres listing both PSV and EDV criteria are linked with a line. The 'measurement method' believed to be used in each centre is also indicated; black triangle=NASCET, black circle=ECST and black square=donot know.

The wide range of PSV and/or EDV criteria for diagnosing 'stenosis >70%' in individual units are displayed in Fig. 2. Fig. 2 also indicates which measurement method the respondent reported was being used in their Unit. For comparison, Table 1 details consensus velocity criteria for diagnosing degree of carotid stenosis according to each measurement method.[5] As expected the PSV and EDV thresholds for diagnosing a NASCET 70% stenosis are significantly higher than those used for diagnosing an ECST 70% stenosis. However, data from the UK audit (Fig. 2) suggest that an almost equal proportion of ECST, NASCET and 'do not know' respondents use a PSV threshold of >230 cm/s as being diagnostic of a 'stenosis >70%'.

Finally, Table 2 summarises the latest North American consensus criteria for diagnosing a NASCET >70% stenosis using ultrasound.[6] Extrapolation of the UK data in Fig. 2, suggests that most units who were not sure as to what measurement method they were using had PSV and EDV criteria that were more consistent with the consensus North American criteria for 'stenosis >70%'. Conversely, at least eight UK units (Fig. 2) who believe they are using ECST based measurement methods have PSV criteria that are virtually equivalent to the North American consensus criteria for diagnosing a NASCET 70% stenosis.

Discussion

The authors concede that there are inherent flaws in the data presented. These primarily relate to incomplete data completion and a failure to ask vascular surgeons (from the same units) as to what measurement methods were applicable and what velocity thresholds were used for planning management. Accordingly, readers should remain cautious about over-interpretation of the findings. However, simple but important messages have emerged from this audit. First, despite being the largest participating country in ECST (i.e. one would intuitively expect the majority of units to use ECST based measurement criteria), the available evidence suggests the converse to be true. Second, the majority of technologists who responded did not know which measurement method was being

Table 2. Consensus panel Gray-Scale and Doppler US criteria for diagnosis of ICA stenosis

Degree of stenosis (%)	Primary parameters		Additional parameters	
	ICA PSV (cm/s)	Plaque estimate (%)*	ICA/CCA PSV ratio	ICA EDV (cm/s)
Normal	<125	None	<2.0	<40
<50	<125	<50	<2.0	<40
50–69	125–230	≥50	2.0–4.0	40–100
≥70 but less than near occlusion	>230	≥50	>4.0	>100
Near occlusion	High, low, or undetectable	Visible	Variable	Variable
Total occlusion	Undetectable	Visible, no detectable lumen	Not applicable	Not applicable

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* Plaque estimate (diameter reduction) with gray scale and colour Doppler US.

used in their unit. However, velocity data from Fig. 1 and Table 2 suggest that most of the 'unknown' respondents were using velocity criteria that were more consistent with a NASCET '70% stenosis' than an ECST '70% stenosis'. If true, more than two-thirds of UK centres currently base decision-making on NASCET (as opposed to ECST) velocity criteria. Moreover, this does not (of course) include other centres who think they are employing ECST based measurement methods, but whose ultrasound criteria for a '>70% stenosis' are actually more consistent with a NASCET '70% stenosis'.

How have these discrepancies arisen. The most likely reason is the evolution of imaging practice over the last 10 years. At the time ECST, NASCET and ACST were recruiting, everyone underwent formal angiography. The method for measuring stenosis (within the trials) was standardised centrally and all of the participating clinicians were aware of which measurement method was being used. In short, although ECST and NASCET may have argued about which was the best measurement method, everyone knew how to apply the respective methods to an angiogram. Since then, routine angiography has been abandoned, principally because of the risk of procedural stroke. At the beginning, this change in practice coincided with a phase of 'internal validation' (comparing Duplex with angiography) in order to ensure that patient safety was not being compromised by this change in practice. However, as the years have elapsed, it has become increasingly difficult to maintain comparative validation, largely because there is now no universally accepted 'gold-standard' (other than the intact plaque) with which to compare duplex and MR angiography etc. It seems likely, therefore, that (with time) velocity criteria have slowly changed within units, possibly following the introduction of new ultrasound technology, comparative studies from elsewhere and new examination techniques.

The second reason for the discrepancies was probably confusion over which measurement technique was being employed. The fundamental problem with the ECST method is that the denominator (the diameter of anticipated outer wall of the bulb) has to be estimated. This contrasts with the NASCET method, which required no 'guestimation'. Accordingly, units may have found it easier to use the NASCET measurement method for validating angiography against ultrasound. Thirdly, not all UK and European centres participated in ECST and many may, quite simply, have always used the NASCET measurement method in their unit.

In North America, it was accepted that consensus criteria were now required to standardise practice around the country. The latest guidelines are summarised in Table 2. Primary criteria for diagnosing a 'stenosis >70%' were PSV >230 cm/s and visible plaque/ lumen narrowing. Secondary criteria included; ICA/CCA PSV ratio >4.0 and EDV >100 cm/s.[2] In the UK (and possibly Europe), it is not going to be possible to achieve similar consensus until we accept one of the measurement methods to be preferable over the other. The current study (despite its limitations) suggests there is too much confusion and considerable variability in diagnostic thresholds to allow this practice to continue unchallenged.

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